

Conflict? What conflict?

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What's the problem?

According to a study of 400 filmgoers by L Mark Carrier, of California State University, 3D movies ... do not offer any advantage over their 2D counterparts (but) watching films in stereoscope increased threefold the risk of eyestrain, headache or trouble with vision. (The Guardian, 11/8/11).

According to Reuters, the Italian government seized 7000 sets of 3-D glasses because they 'did not display tags proving they would not cause short-term vision problems to users'.

Nintendo have issued a warning that their new hand-held 3DS should not be viewed in stereoscopic mode by children 6 years and under. This follows similar warnings by other manufacturers, e.g. Samsung and Sony, about the use of their 3-D stereoscopic equipment.

What does the literature say?

The prevailing idea in the literature at the moment is that the problem is a 'conflict' between the stimulus to accommodation and the stimulus to convergence.

What does the literature say?

“Conflict between accommodation and convergence is one of the most dominant factors leading to visual fatigue in viewing three-dimensional display”

Kim, Hong, Lee, Kim, Yang & Hwang. Proc. SPIE 7956, 79560Q (2011)

“the uncoupling of vergence and accommodation required by 3D displays frequently reduces one's ability to fuse the binocular stimulus and causes discomfort and fatigue for the viewer.”

From: Vergence–accommodation conflicts hinder visual performance and cause visual fatigue Hoffman, Girshick, Akeley & Banks (2008) Journal of Vision

“It is generally agreed that excessive parallax causes visual discomfort”

From: Stereoscopic 3D-TV: Visual Comfort in: IEEE Transactions on Broadcasting, 2011 Tam, Speranza, Yano, Shimono & Ono

What does the literature say?

BUT:

The visual effects of head-mounted display (HMD) are not distinguishable from those of desk-top computer display, Peli (1998)
Vision Research, 38:13

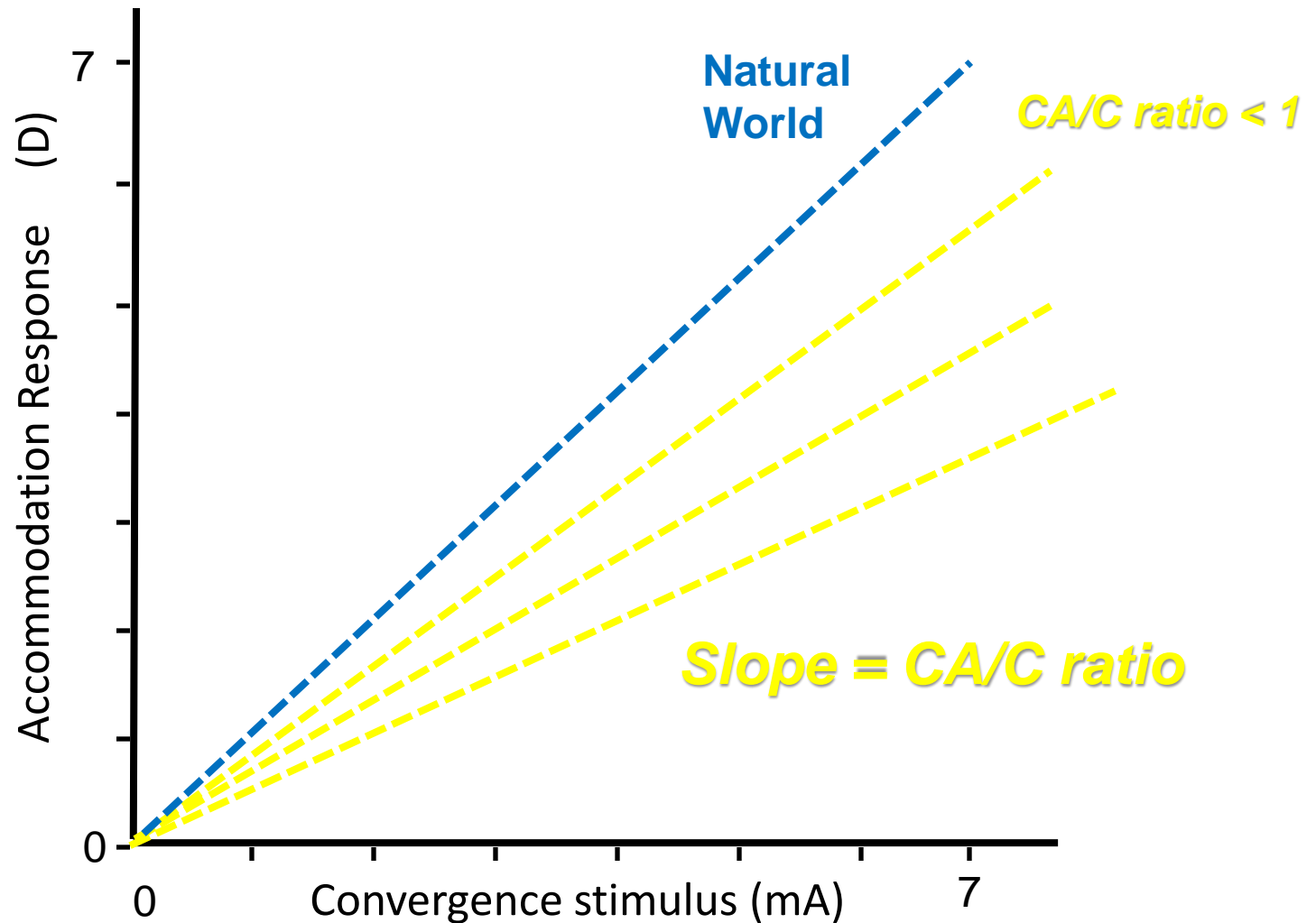
“.. accommodation-convergence conflict appear to be of minor importance when disparity values do not surpass one degree limit of visual angle” *Lambooij, et al. (2007)*

“From our knowledge of the zone of clear, comfortable, single binocular vision we can say that this discrepancy is unlikely to lead to asthenopic symptoms if it is small, but is likely to do so if it is large, and what constitutes ‘large’ and ‘small’ are idiosyncratic to the individual.”
(*Howarth, 2011*)

The Eye's behaviour in the 'Natural' world: accommodation

- The sensorimotor systems of the eye act to provide a clear, single image. When looking at a near object the eyes have to accommodate (focus) and converge (turn inwards) in order to achieve this.
- The accommodation and convergence systems (along with the pupillary system) are intrinsically-linked (and because near vision changes affect all three they are together termed the 'near triad').
- If one converges then the eye automatically accommodates ('convergence-accommodation') and the optical power of the lens increases.
- The knowledge that one is looking at a near object (or into an optical instrument) also provides what is termed 'proximal' accommodation.

The accommodation provided by the proximity, plus that provided by the vergence system in the absence of a blur stimulus (i.e. 'open loop')



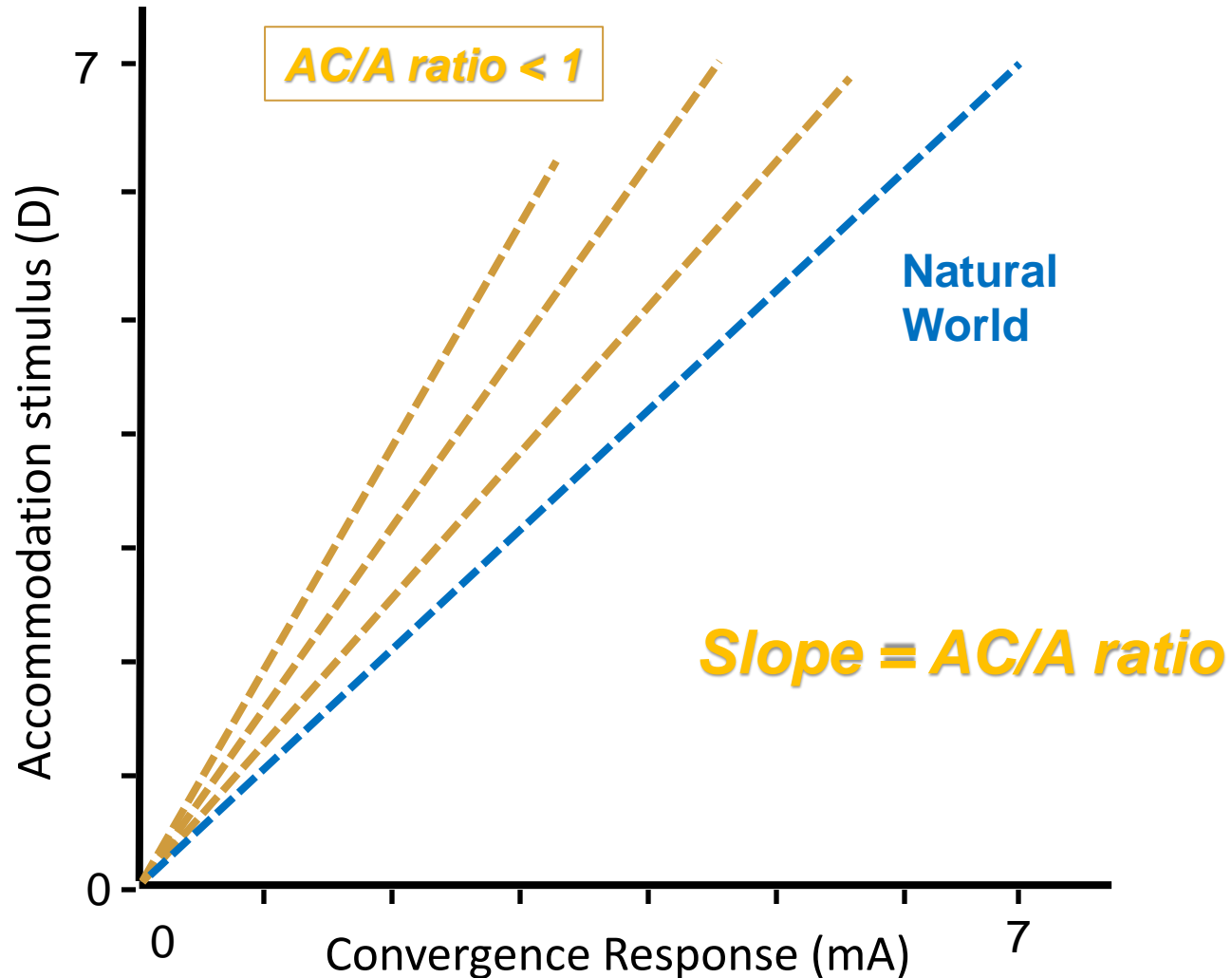
The Eye's behaviour in the 'Natural' world: convergence

- The sensorimotor systems of the eye act to provide a clear, single image. When looking at a near object the eyes have to accommodate (focus) and converge (turn inwards) in order to achieve this.
- If one accommodates, then the eyes automatically turn inwards ('accommodative-convergence').
- The knowledge that one is looking at a near object (or into an optical instrument) also provides 'proximal' convergence.

The Eye's behaviour in the 'Natural' world

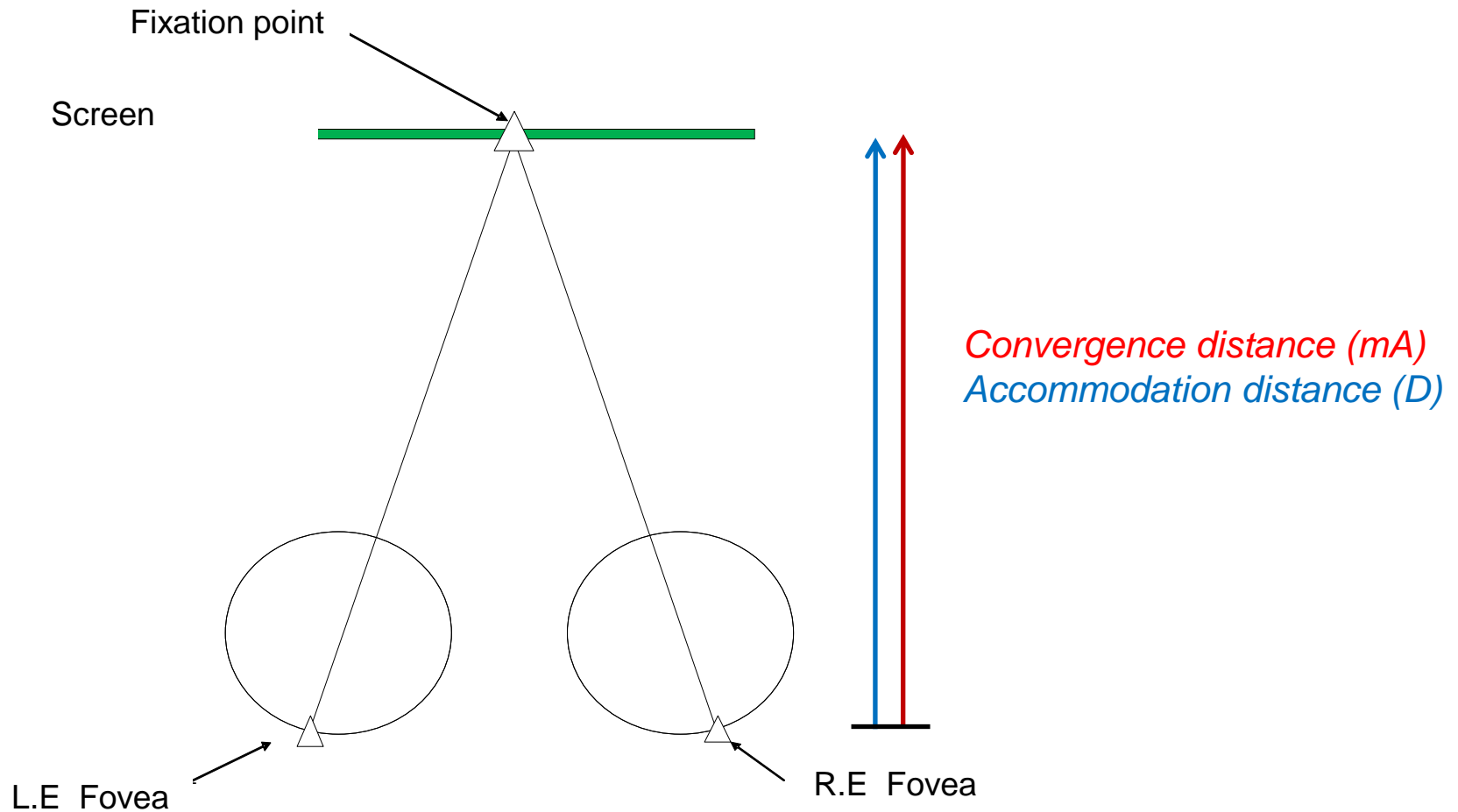
- When dead, our eyes take up an anatomical position of rest.
- When asleep, our eyes take up a physiological position of rest
- When awake, a number of factors will affect the position of the eyes (and the point at which they converge, if they do)
- Eye position is altered by:
 - Muscle tone, and any adaptation setting
 - Knowledge of proximity of the stimulus
 - The use of optical instruments
 - The accommodative state of the eye
- 'Fine tuning' is then performed by the vergence system to provide single vision.

**The convergence provided by the accommodation system
in the absence of a disparity stimulus (i.e. 'open loop')**

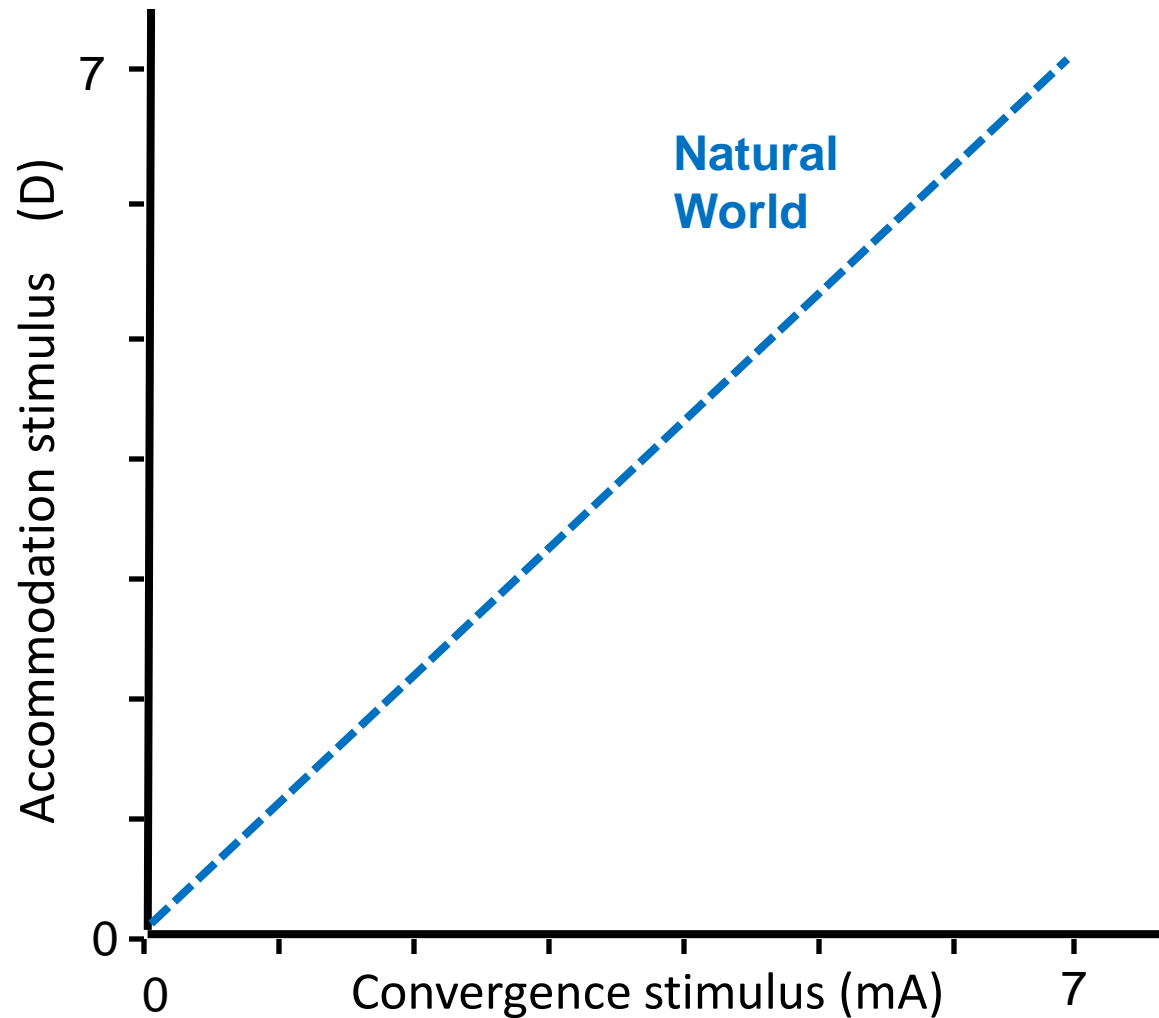


- A *single* image is achieved by the convergence system being driven by accommodation, (and other drivers, such as the knowledge of nearness [proximal convergence]) with the 'fine tuning' being achieved by disparity-driven convergence.
- A *clear* image is achieved by the accommodative system being driven by convergence (and other drivers, such as the knowledge of nearness [proximal accommodation]) with the 'fine tuning' being achieved by blur-driven accommodation.
- In the natural world, the stimulus to accommodation (in Dioptres) and the stimulus to convergence (in reciprocal metres [mA]) are numerically identical. This is because the eyes are looking at a real object.

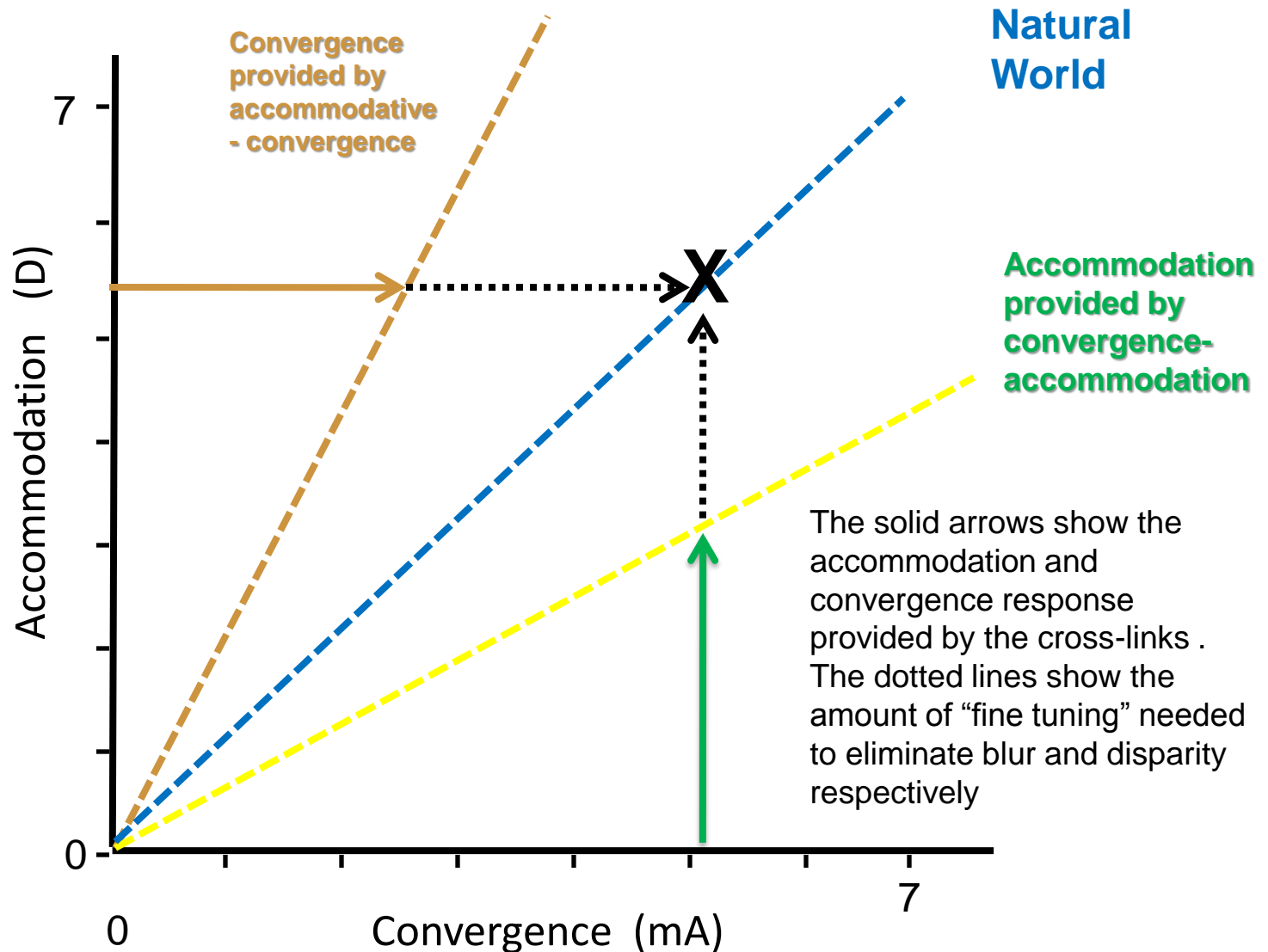
The 'natural world' (in this case a normal 2D display)



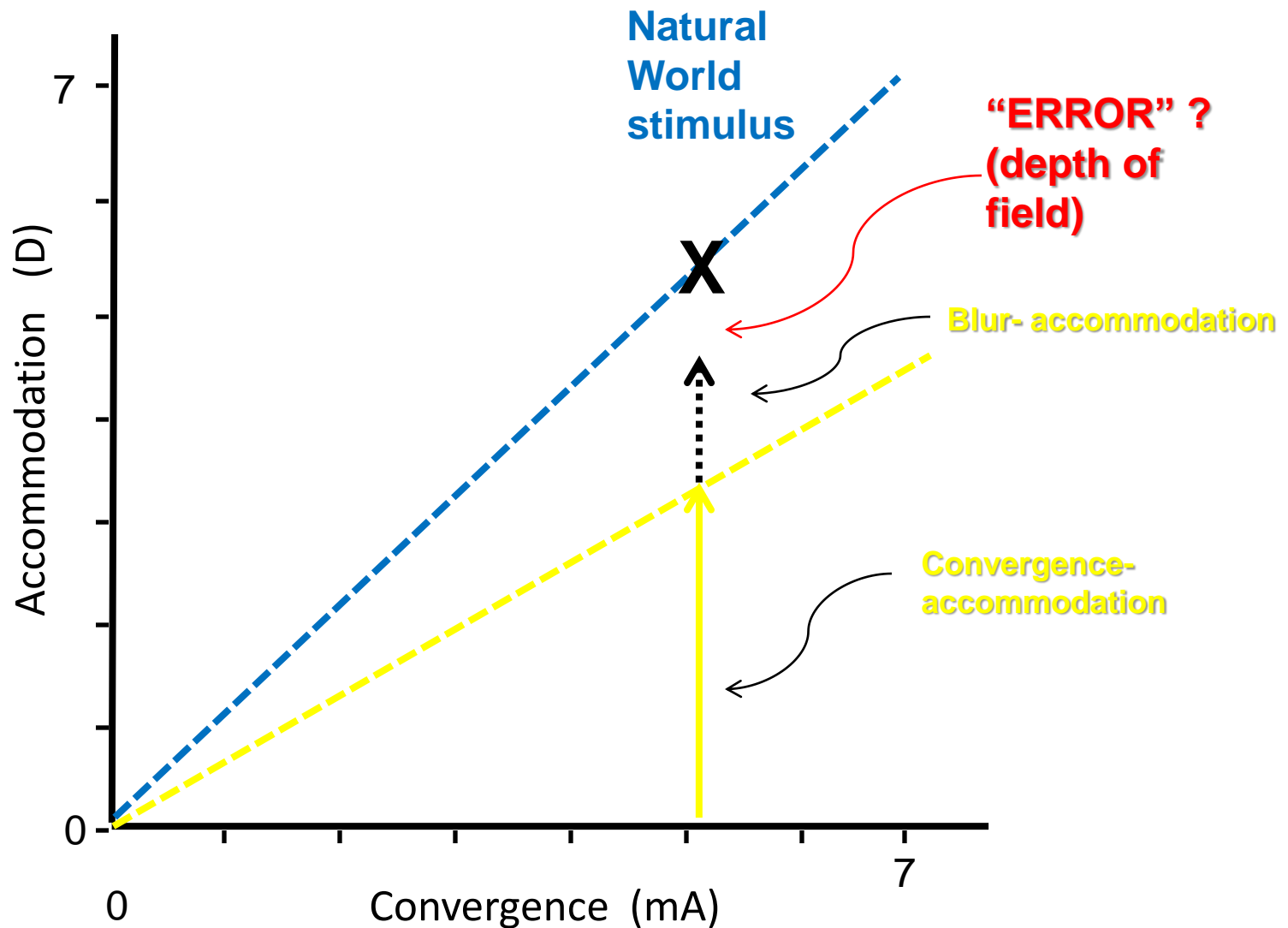
The Stimulus to accommodation and convergence provided by the **'natural world'**



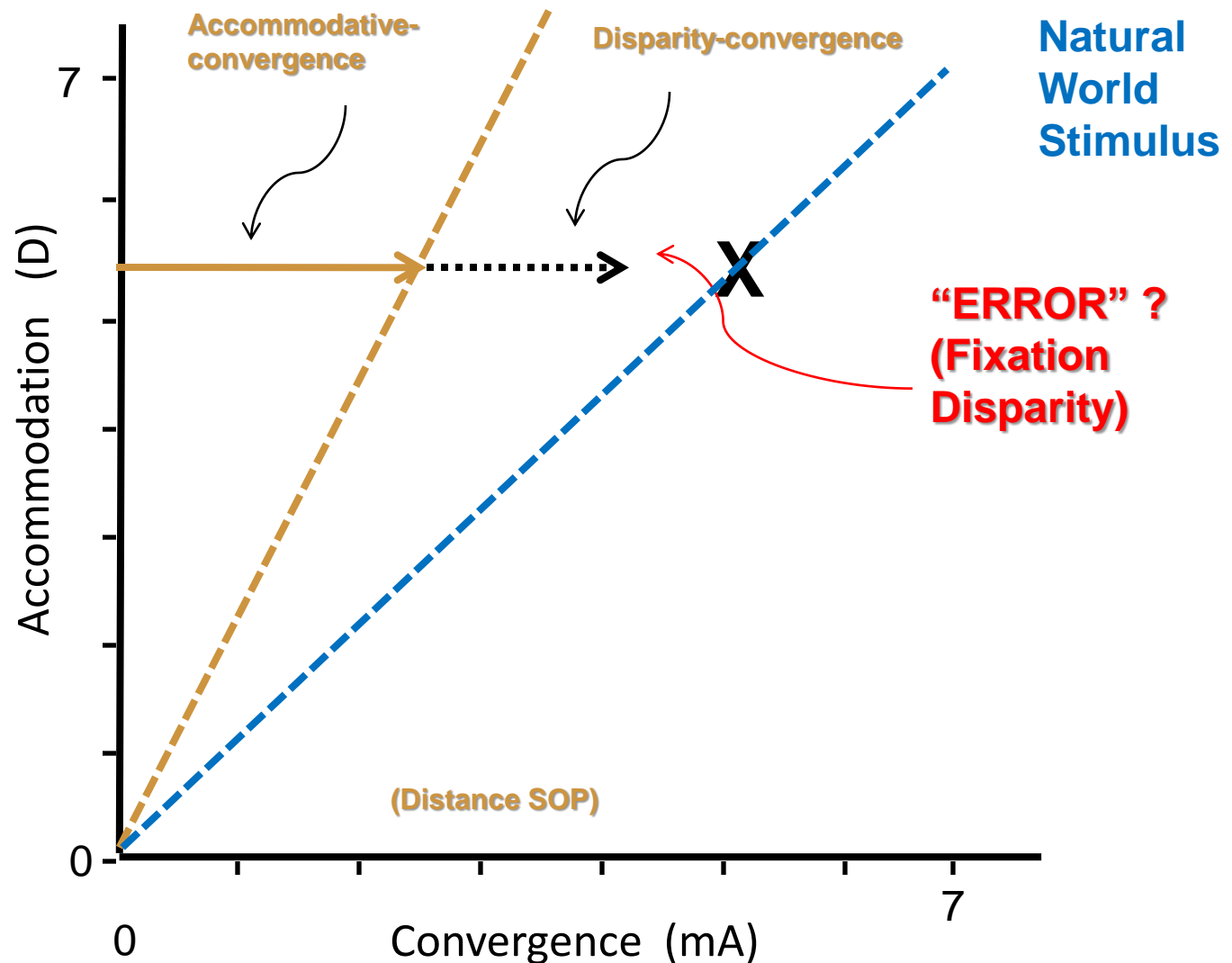
The 'ideal' response of the accommodation and convergence systems in the natural world



The *actual* response of the accommodation system in the natural world



The *actual* response of the convergence system in the natural world



A 3D stereoscopic display

Position of the image seen in stereopsis

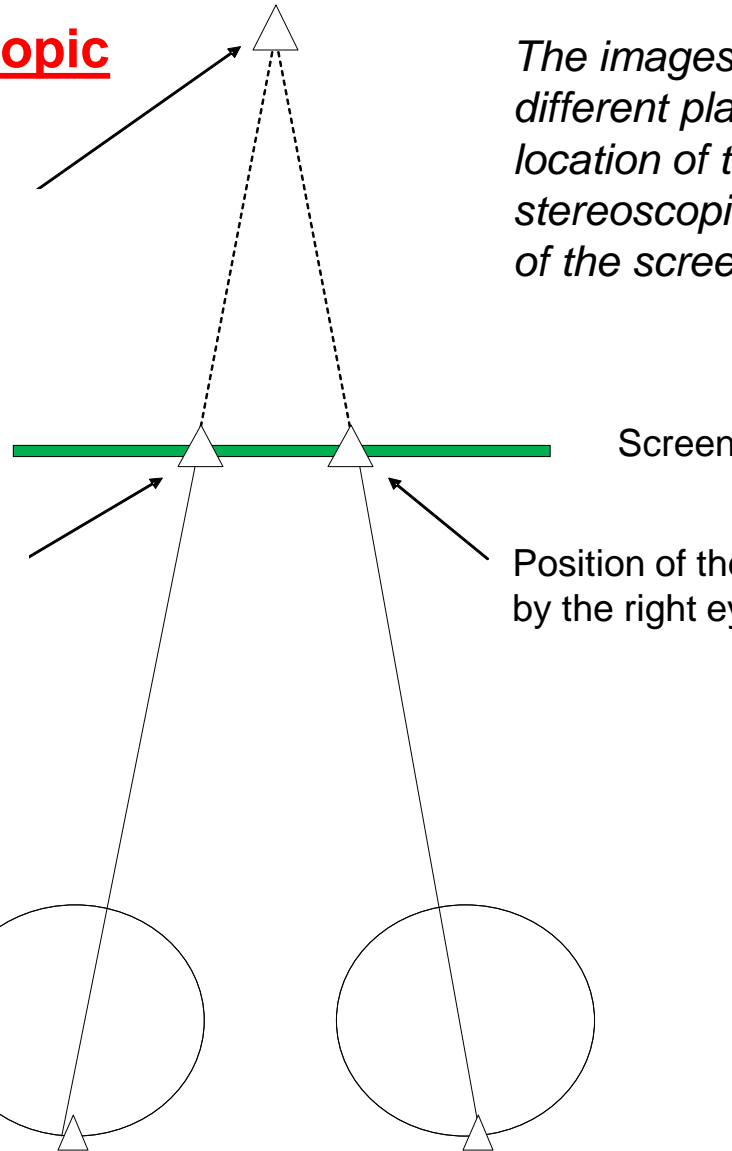
The images on the screen are located in different places. Consequently, the location of the geometric image, seen stereoscopically, lies away from the plane of the screen

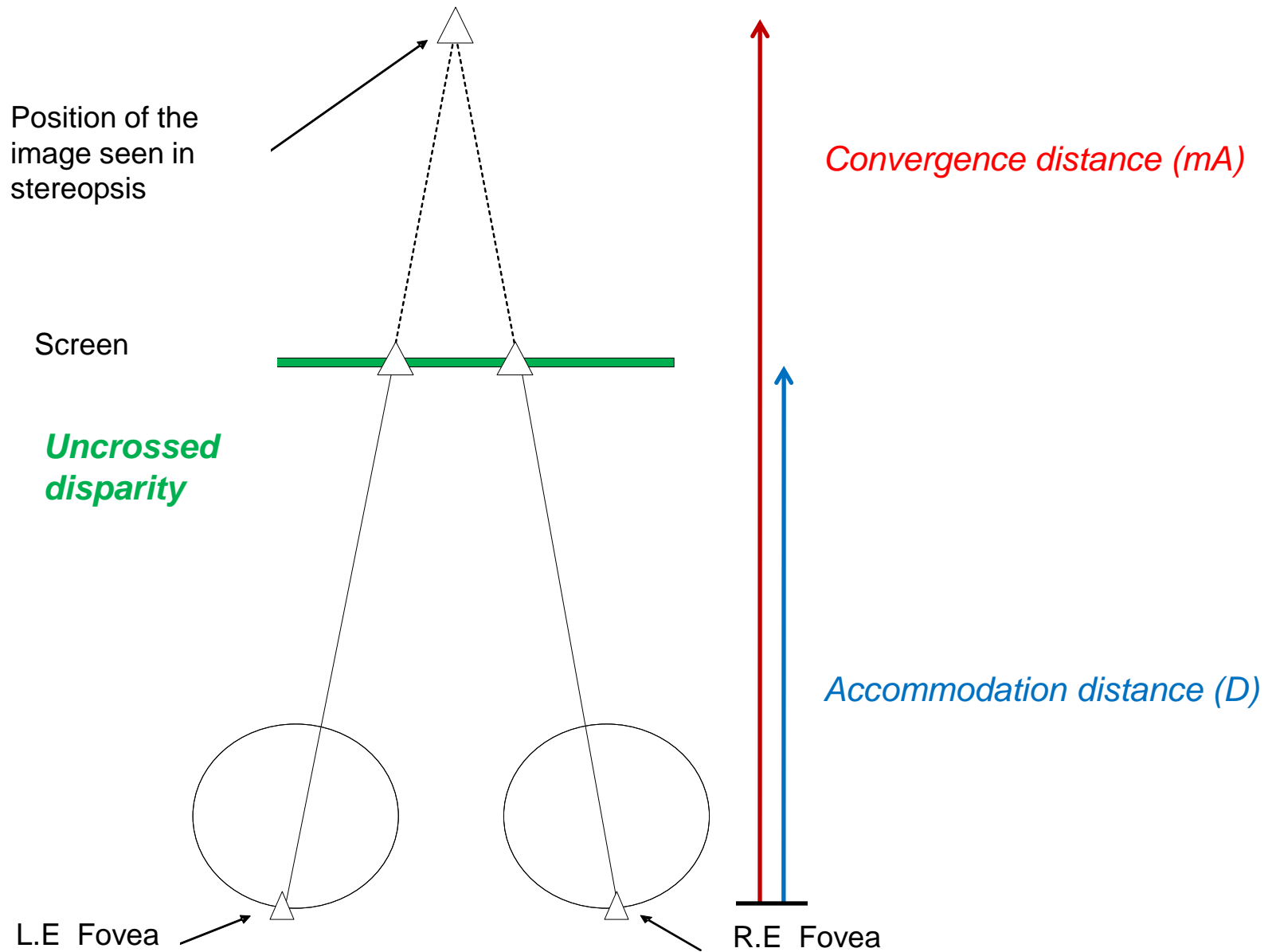
Position of the image seen by the left eye

Position of the image seen by the right eye

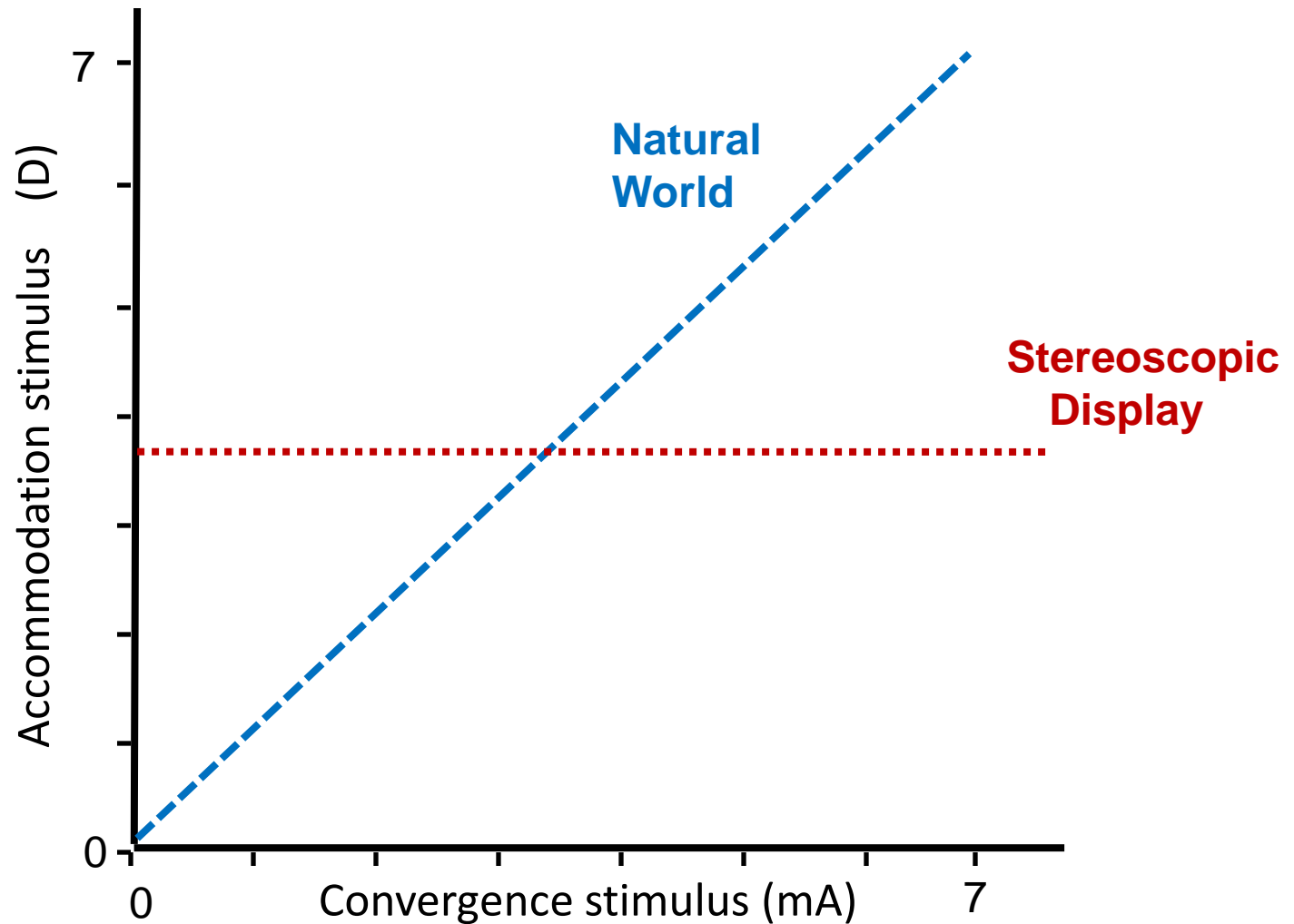
L.E Fovea

R.E Fovea

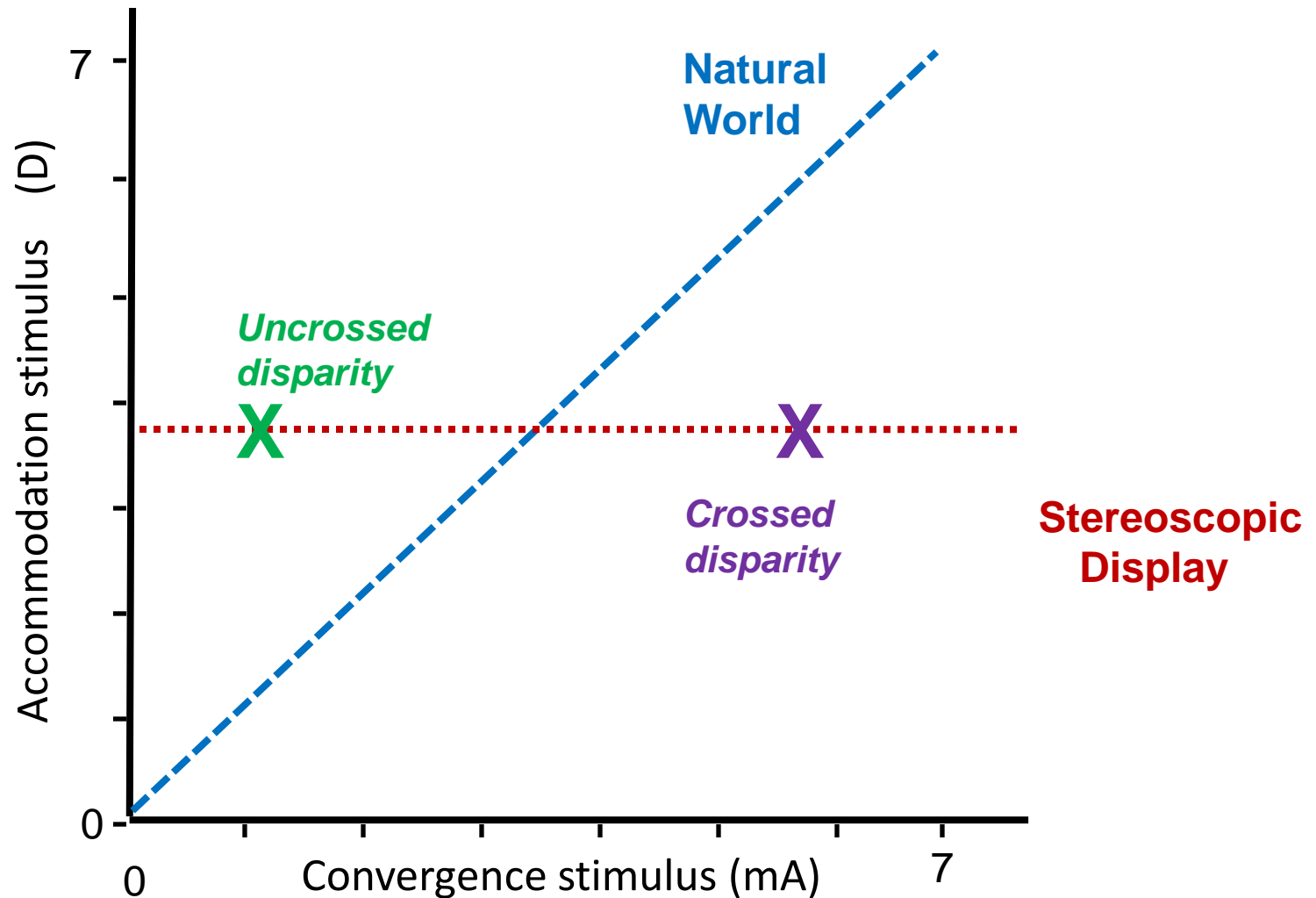




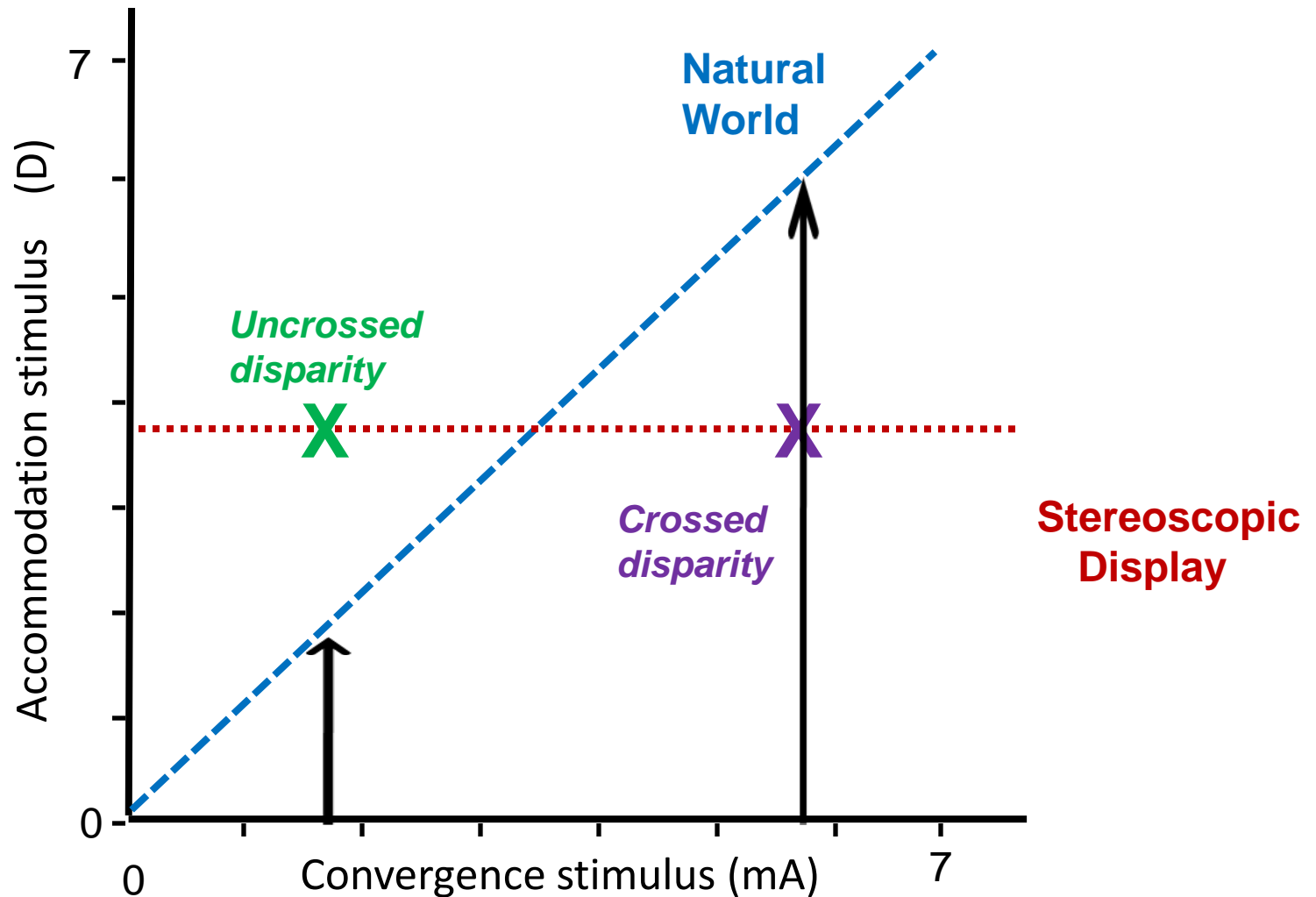
The Stimulus to accommodation and convergence provided by the **'natural world'** and by a **3D stereoscopic display**



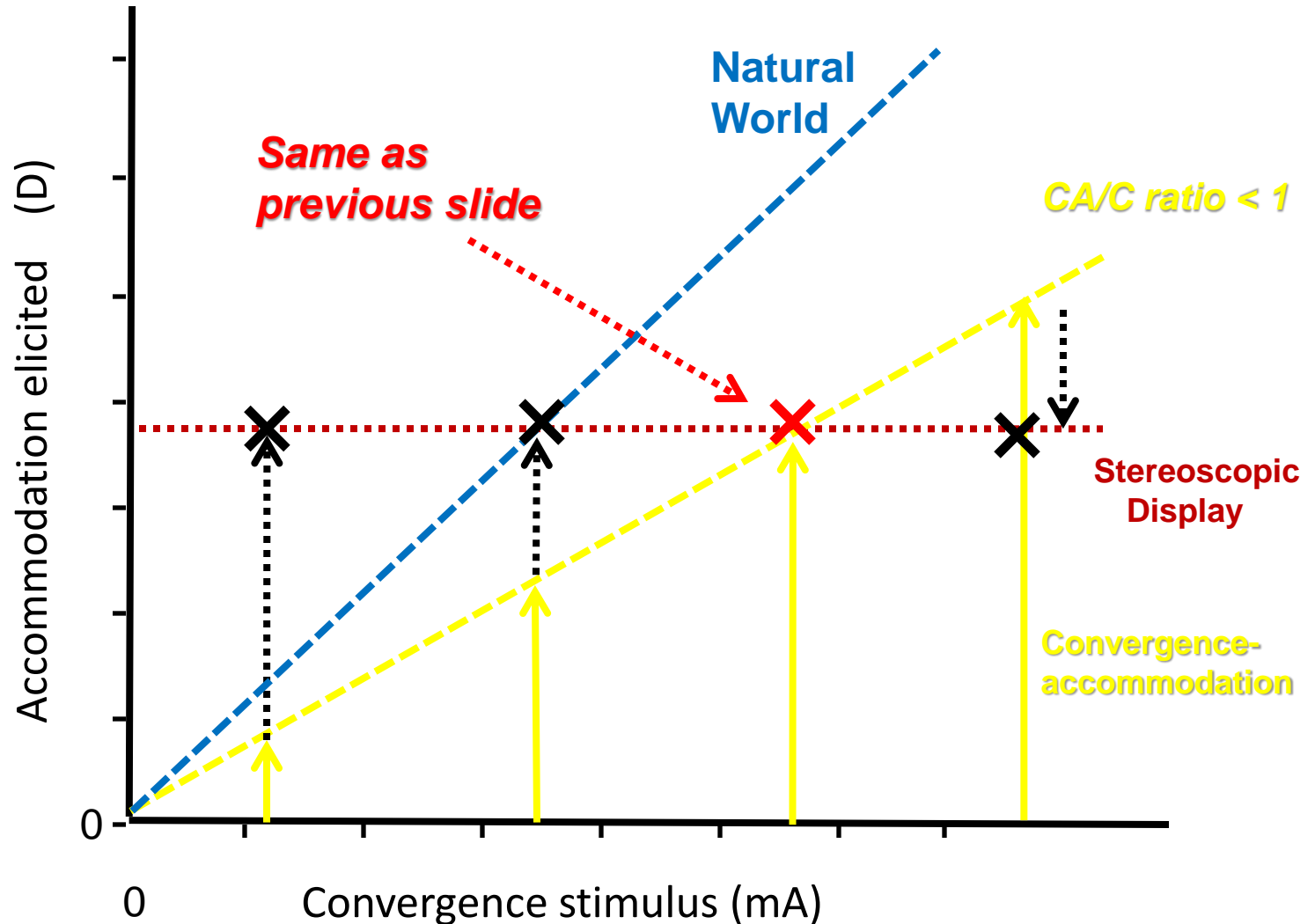
The Stimulus to the vergence system provided by an image in front (crossed) or behind (uncrossed) the screen



The Difference in the accommodation 'expected' on the basis of the convergence stimulus.



The demands on convergence-driven accommodation (yellow arrow) and blur-driven accommodation (black arrow) when the eye is focussed at the screen distance.



Where is the conflict?

- The 'conflict' is in the stimulus and not in the response
- But surely it is the *response* of the visual system that provides symptoms (or not) and not the *stimulus*
- *With regard to accommodation, what is different about the 3D stereoscopic stimulus is the relationship between the demands on convergence-driven accommodation and blur-driven accommodation*

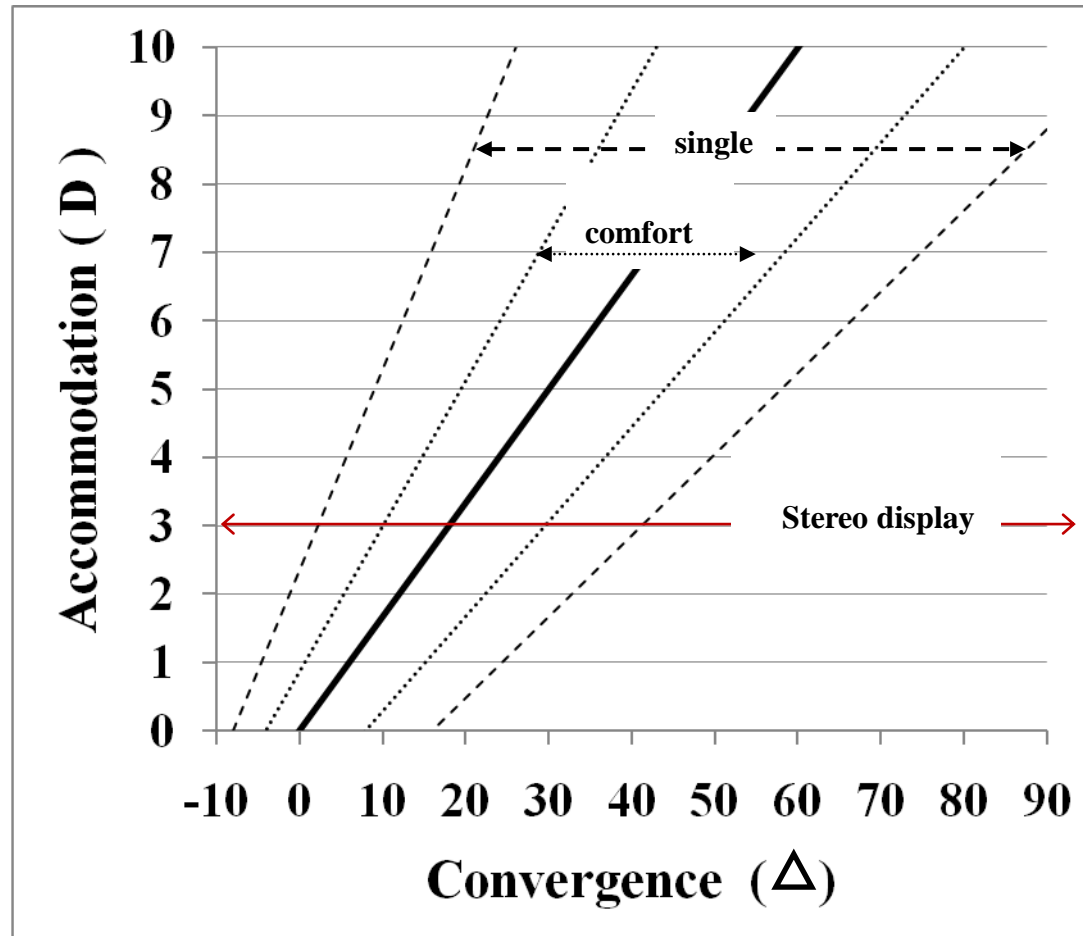
Where is the conflict?

- EXACTLY the same argument applies to the convergence system
- *What is different about the 3D stereoscopic stimulus is the relationship between the demands on accommodation-driven convergence, and disparity-driven convergence*

My point is that it is these responses we ought to be investigating, and not the stimulus per se.

The Comfort Limits: Optometric Knowledge

When we alter the convergence stimulus, we change the ratio of Convergence Accommodation: Blur Accommodation needed



Conflict ?

What conflict?

The so-called “Accommodation-Convergence Conflict”

The stimulus to accommodation and the stimulus to convergence are the same in the real world, but different in a 3D stereoscopic display.

Some people who look at a 3D display report experiencing various symptoms

Therefore the problems are caused by this conflict

My Hair

Before I met my children's mother my hair was brown

My hair is now grey

Therefore my hair has changed colour because of her

My Car

My current car is black in colour, my previous one was blue

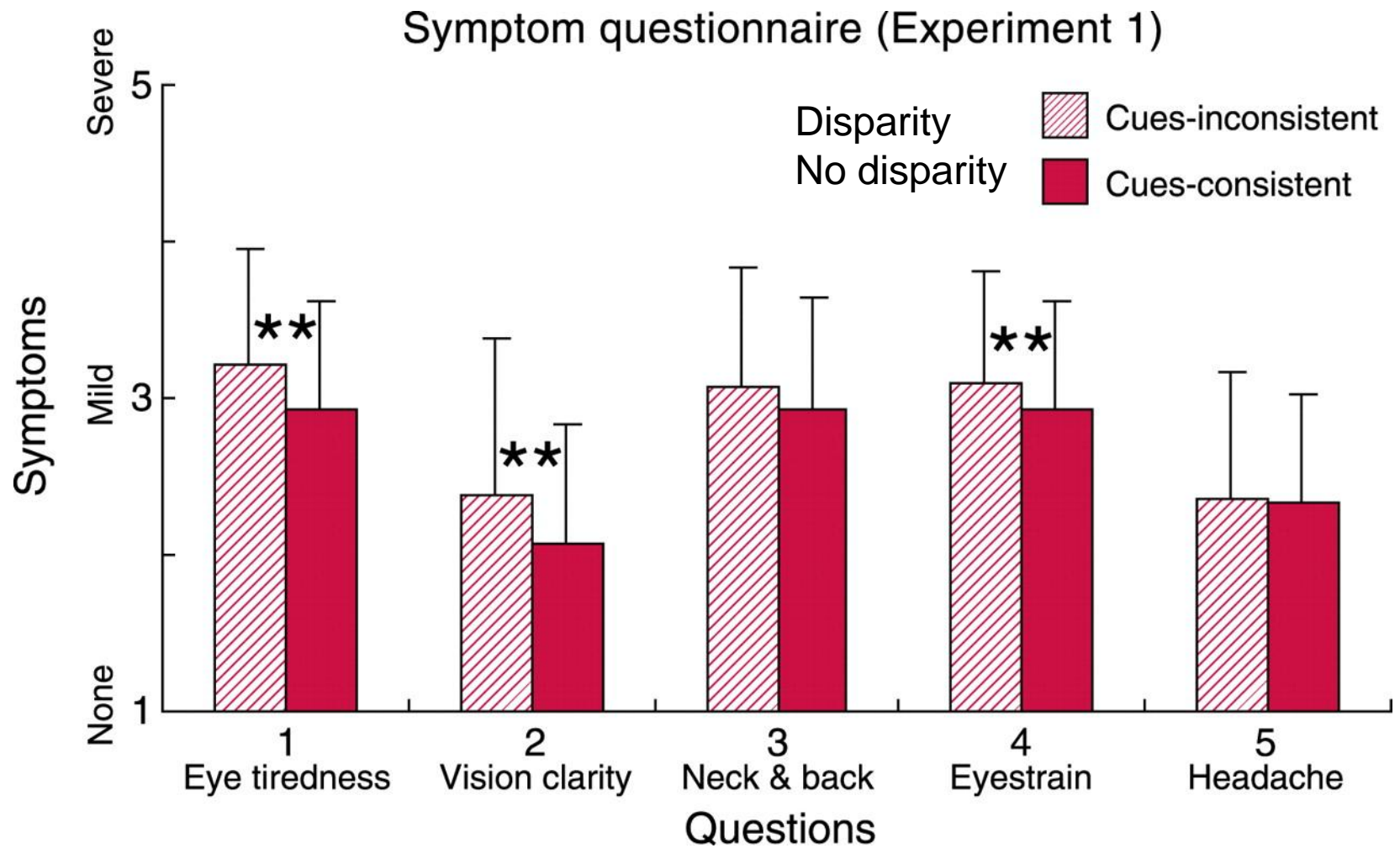
The fuel consumption of my current car is better than that of my previous one

Therefore blue cars use more fuel than black cars

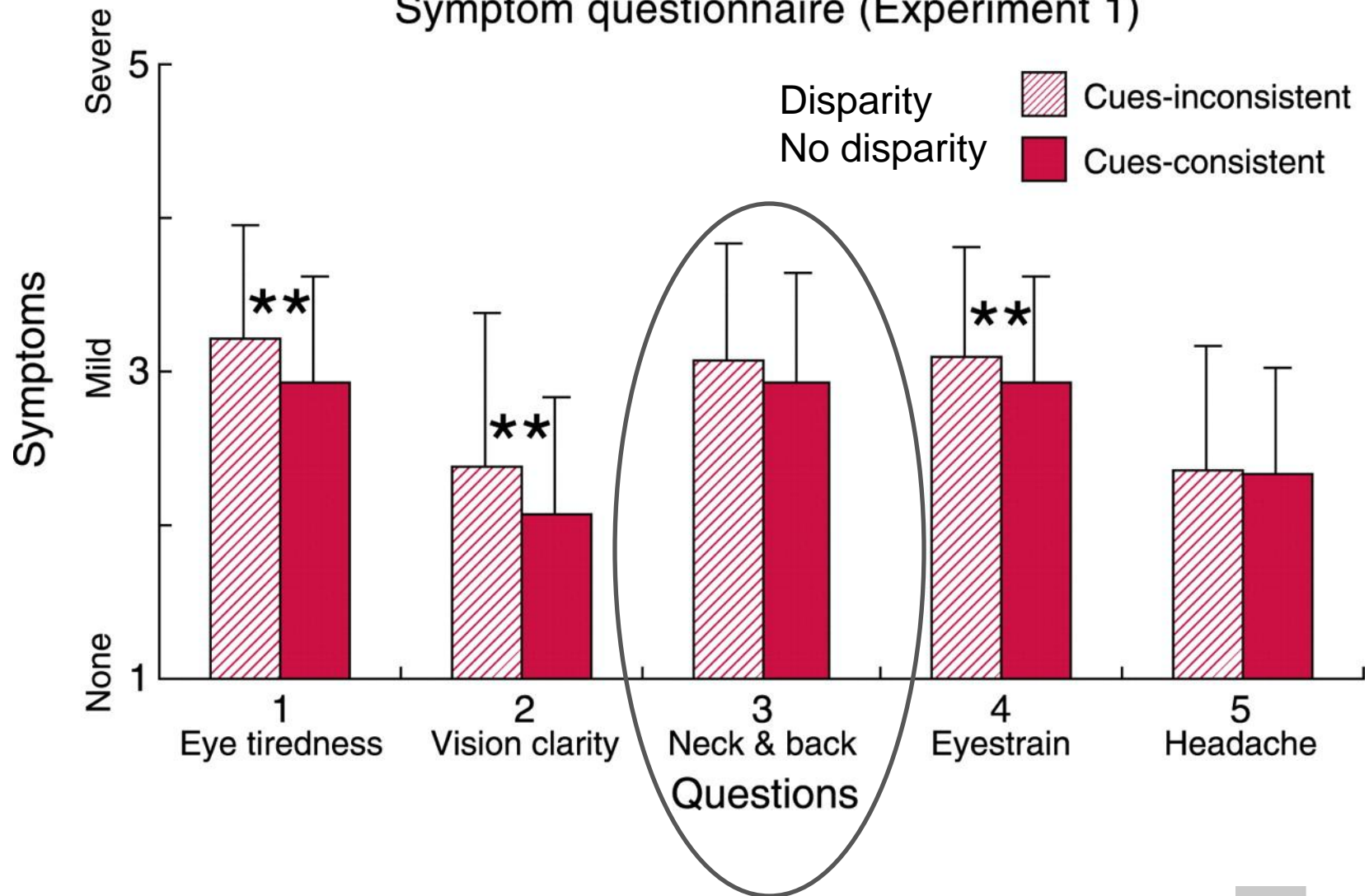
Thank You

Do the differences in the demands on the accommodation or the convergence systems lead to visual fatigue or headaches?

- What we are doing is varying the demands on the different inputs to the accommodation system and the convergence system, and we would expect people to differ in their tolerances.
- Averaging data would then give a misleading picture of the issue



Symptom questionnaire (Experiment 1)

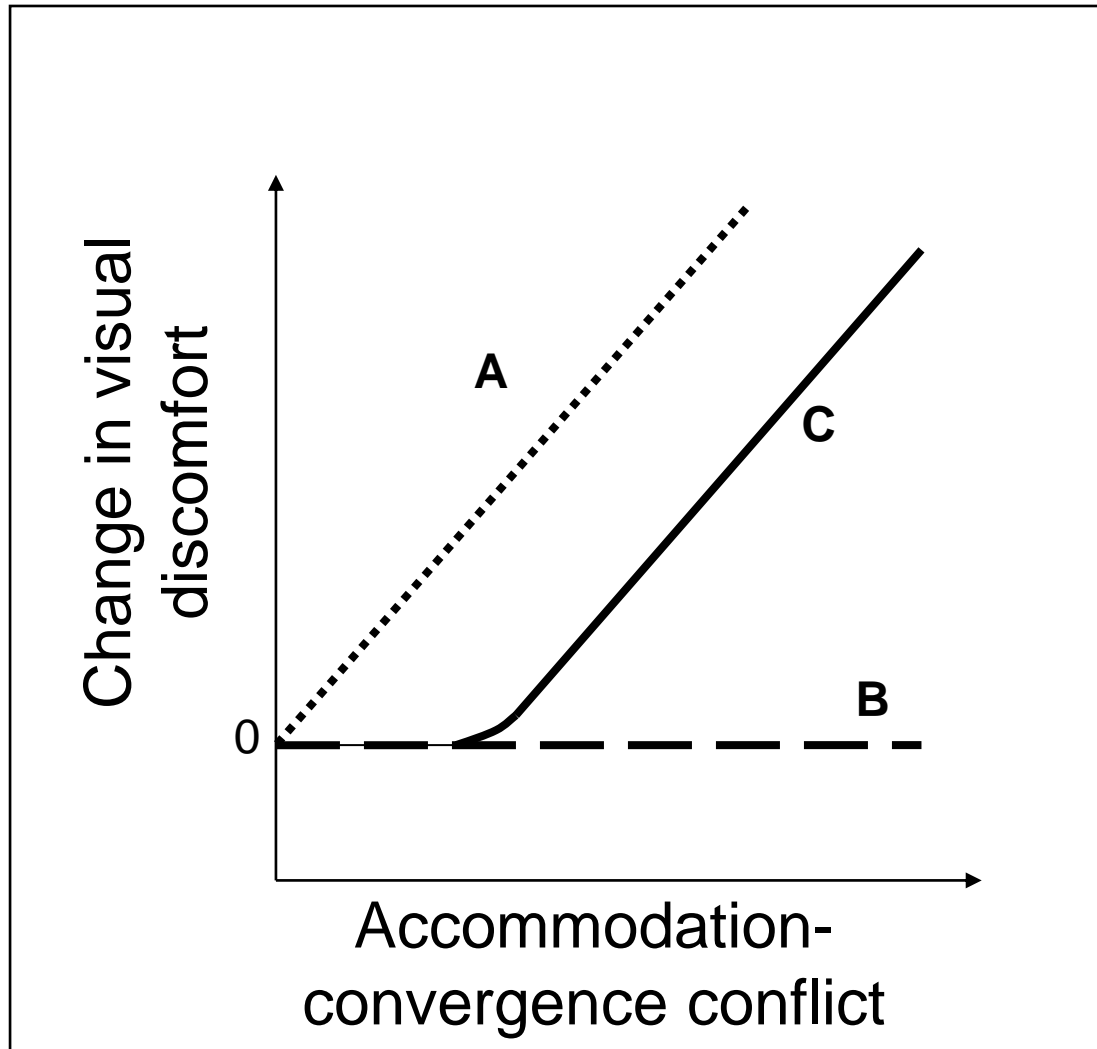


From:

The Impact of Viewing Stereoscopic Displays on the Visual System

Peter A. Howarth and P. J. Underwood

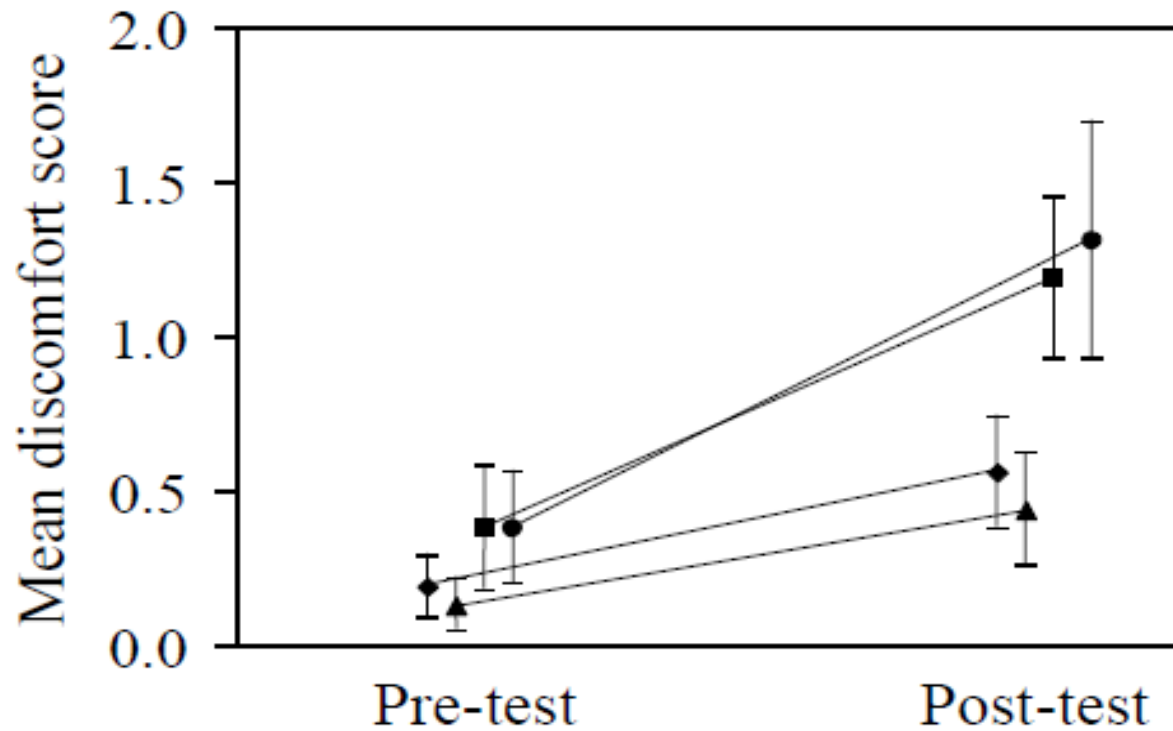
**Joint Virtual Reality Conference of EGVE – EuroVR 2011
pp. 19-25**



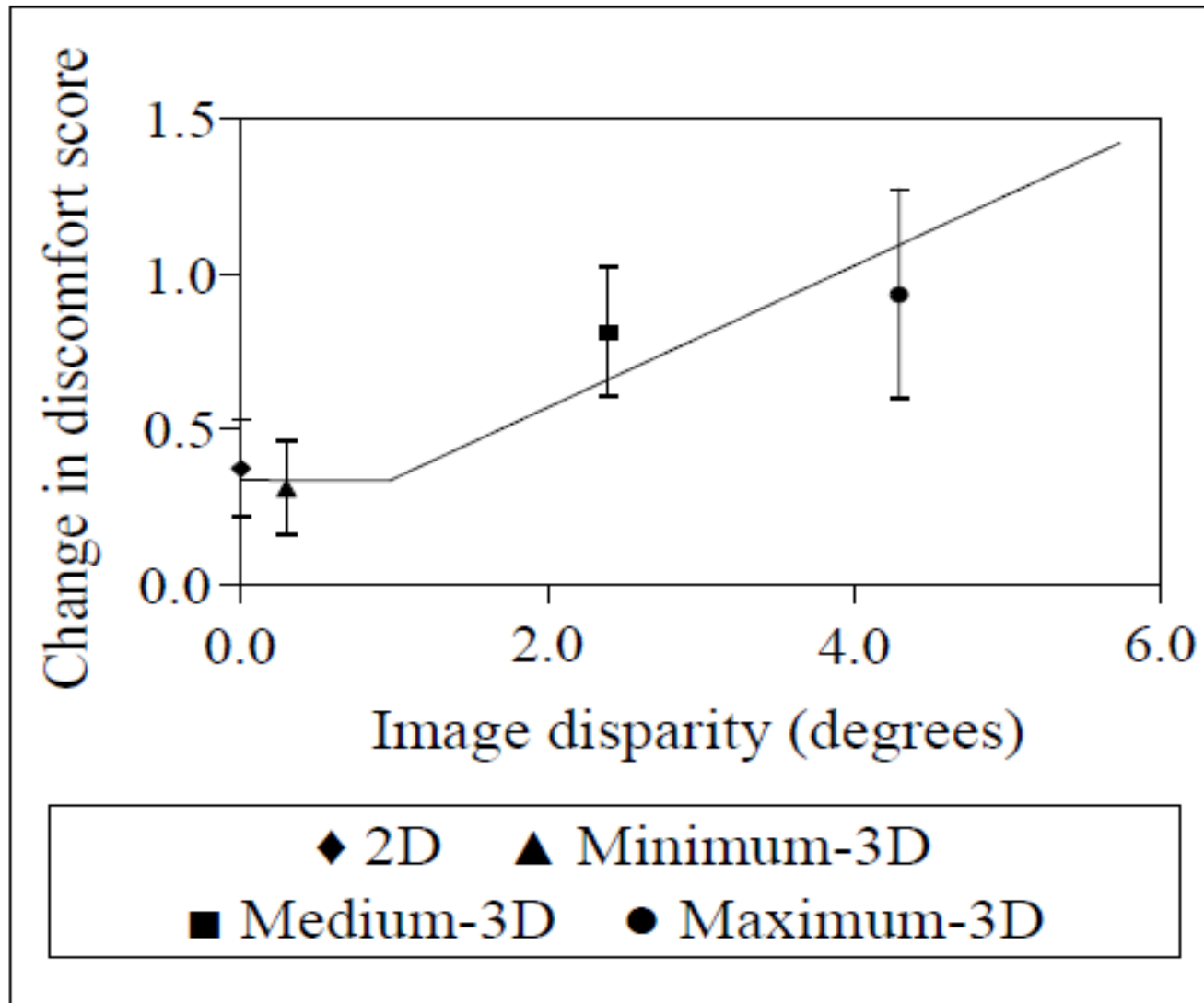
: *Three models of the relationship between the accommodation-convergence conflict and visual discomfort.*

Experiment

- Task: play a computer game (without vection)
-
- **4 conditions:**
 - **Disparity 0 (i.e. 2D) , 0.3°, 2.4°, 4.3°**
- 16 unpaid participants, mean age 28.6 yrs (20-47)
 - Normal vision
- 20 minute sessions
- Subjective questionnaire data
- Non-parametric analysis of the statistics



◆ 2D ▲ Minimum-3D
■ Medium-3D ● Maximum-3D



Results

	Condition			
Change in discomfort score	2D	Minimum-3D	Medium-3D	Maximum-3D
0	11	12	7	9
1	4	3	5	3
2	1	1	4	1
3	0	0	0	2
4	0	0	0	1

Results

	Condition			
Change in discomfort score	2D	Minimum-3D	Medium-3D	Maximum-3D
0	11	12	7	9
1	4	3	5	3
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4	0	0	0	1

Revised model of the relationship between the accommodation-convergence “conflict” and discomfort

